OFFICE OF NUCLEAR REGULATORY RESEARCH

LOCA Ductility Tests

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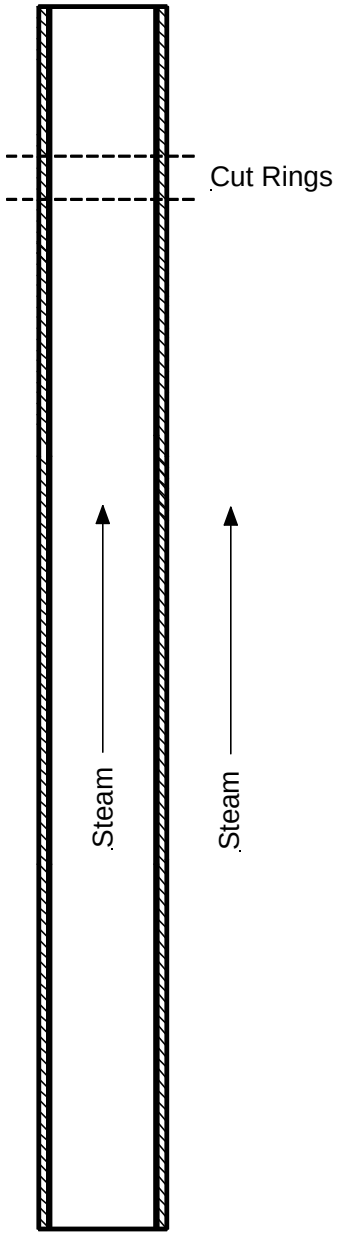
with illustrations by Nicolas Waeckel, EdF

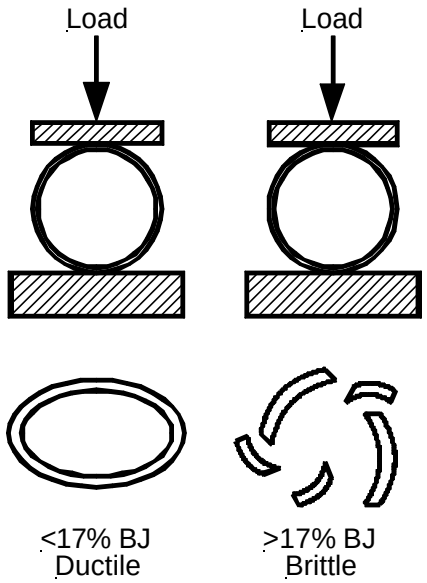
Ring-Compression Tests

Ring Tests



Oxidize at 1000 - 1200 C

Test Rings at 135 C

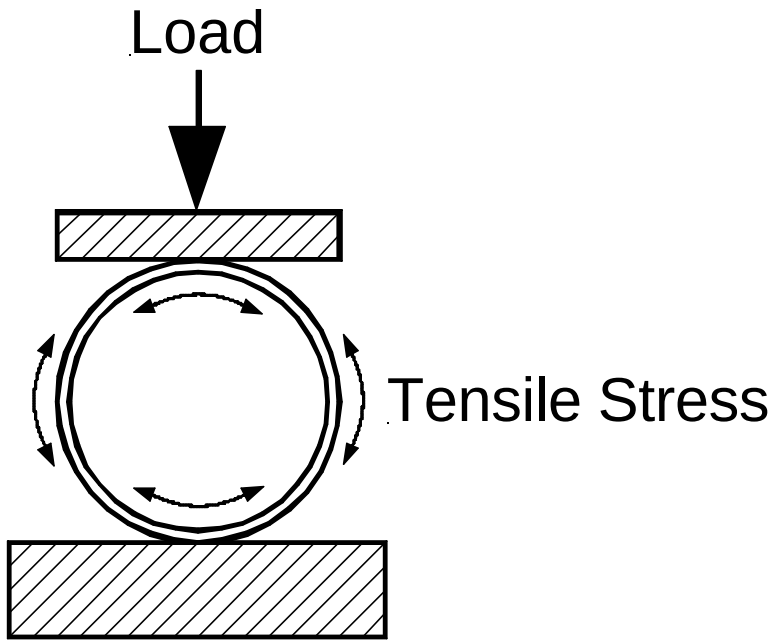


<17% BJ
Ductile

>17% BJ
Brittle

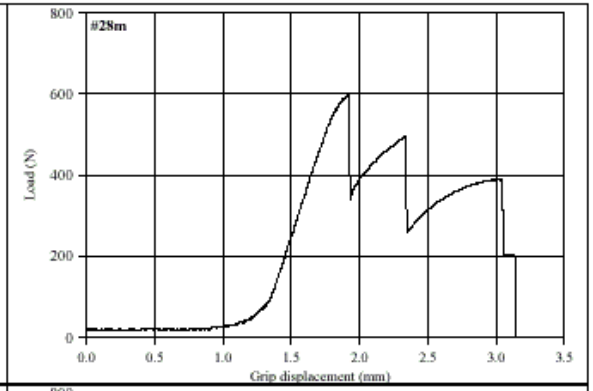
BJ = Total Oxidation Calculated with Baker-Just Correlation

Large OD and ID tensile stresses in ring between flat plates

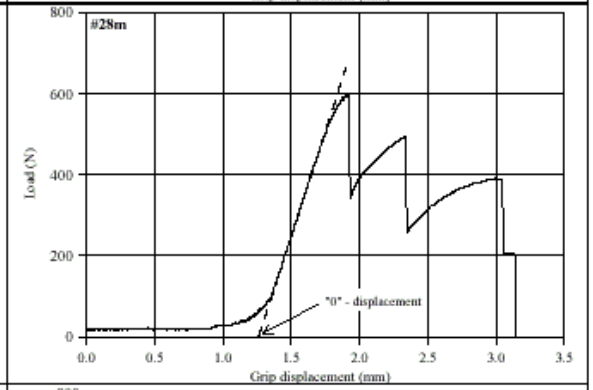


Load-vs-displacement curve for ring-compression tests showing Kurchatov method of analyzing results

1) Load-displacement diagram as measured



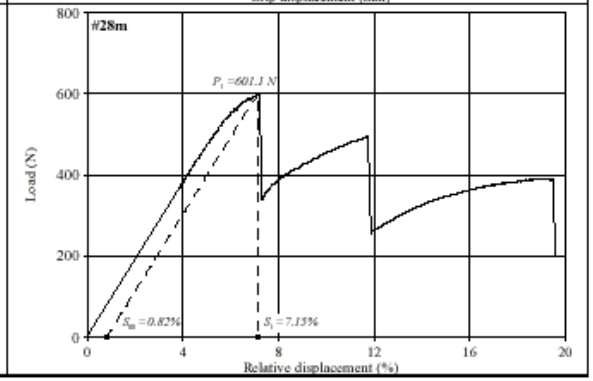
2) Determination of origin of a scale for the displacement



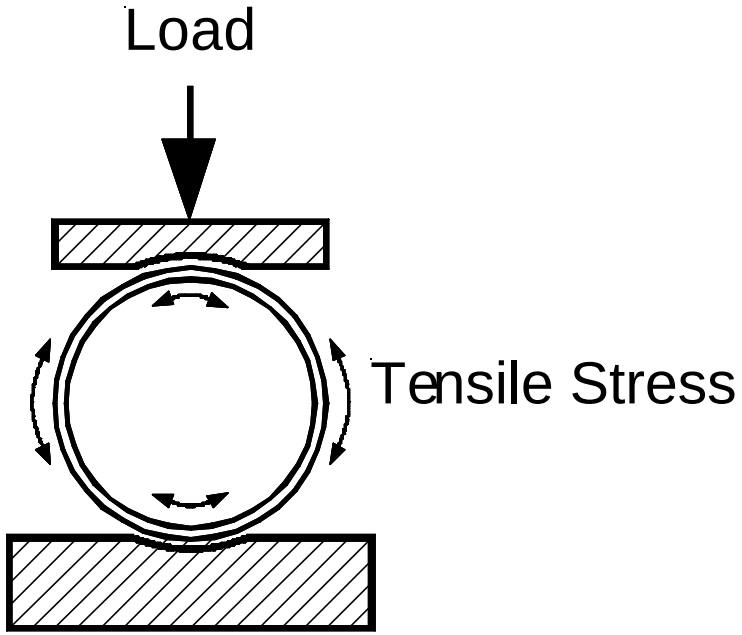
3) Final version of the diagram

$S=\Delta l/D_0\,100\%$,

where:
S – relative displacement;
Δl – displacement;
D_0 – outer diameter of Zr-1%Nb sample
Diagram legend:
S_f – relative displacement at failure;
S_{pl} – plastic component of relative displacement;
P_f – load at failure

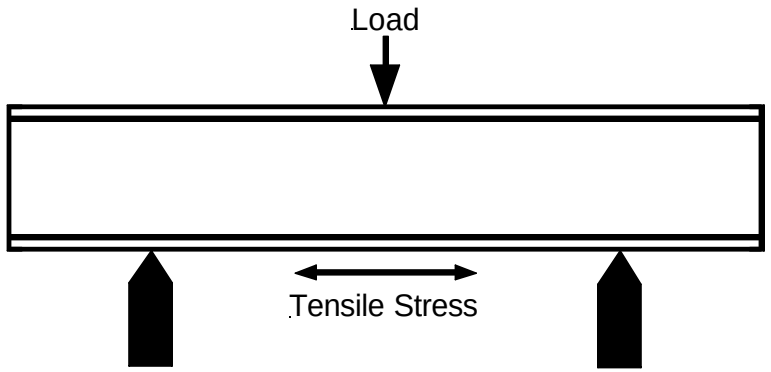


Smaller ID tensile stresses in ring between curved plates

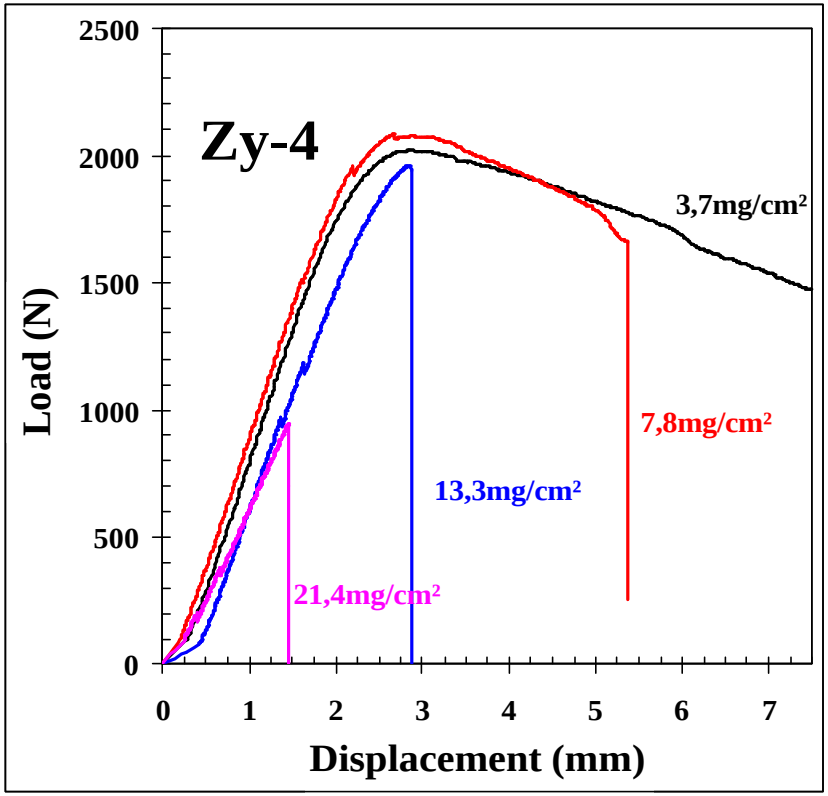


Three-Point Bend Tests

Three-point bend test with tensile stress on lower OD surface

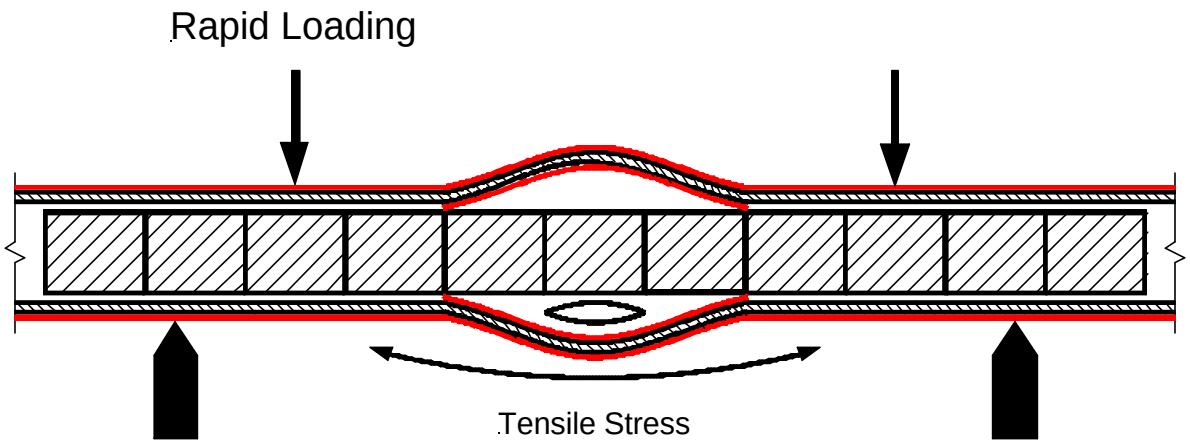


Load-vs-displacement curve for four Framatome three-point bend tests

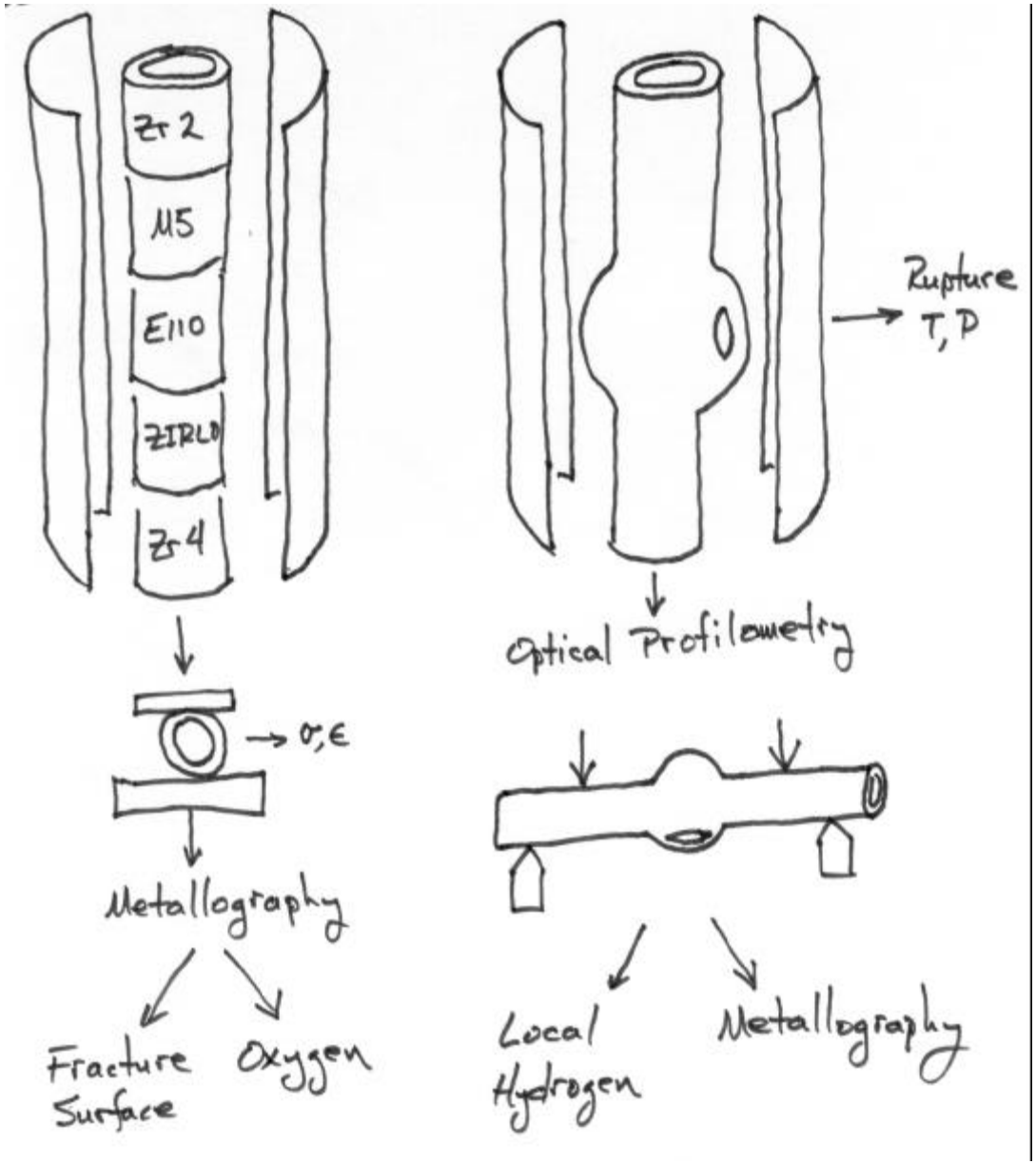


Four-Point Bend Tests

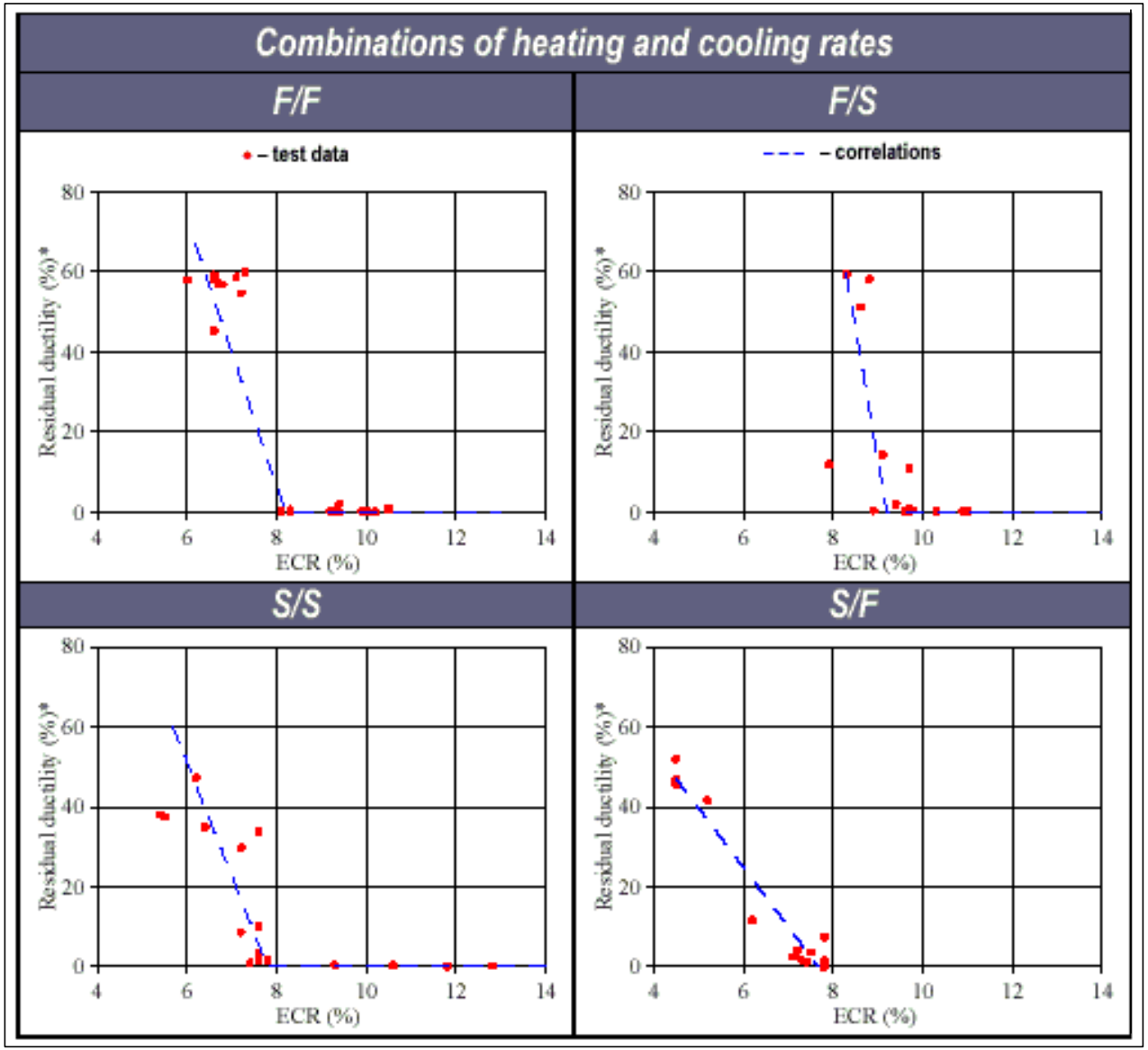
Four-point bend test on ballooned and ruptured segment of rod containing fuel; tensile stress on lower OD surface



Schematic diagram of testing sequence



Residual ductility versus oxidation for four Kurchatov combinations of heating rates



SUMMARY

- Preparations for ring-compression testing are underway
- Zircaloy-2, Zircaloy-4, M5, and E110 tubing are at Argonne
- Negotiations are underway with Westinghouse for ZIRLO tubing
- Unirradiated tests and assessment of results to be completed by December 2003